**OUTLINE FOR TEACHING TONLE SAP MIMES**

**HYDROLOGY**

**System learning goals:** Recognize the dynamic nature of climate and hydrology in this system and consider the relevant deterministic factors that are known to drive hydrological cycles in the system including (1) interdecadal climate cycles (eg ENSO), (2) recent water infrastructure development projects, (3) global warming. The exercise will help users to be able to distinguish among different temporal signals in hydrological data: cyclical functions, linear functions, and variability.

**Decision support goals:** Determine which baseline(s) are relevant to consider for sustainable decision making and how those baselines should be interpreted. Users will consider how to apply results in a decision making context. Users will explore the implications of results for selecting relevant decision making baselines.

**Modelling skills goals:** Understand how to input and view time series MIMES. Examine model equations for summarizing hydrological metrics. Compare model MIMES model output to other relevant research findings.

**Background:**

Climatological cycles

* Strong link between ENSO and Mekong River metrics of wet season precipitation and river discharge suggested (Delgado et al 2012, Rasanen and Kummu 2013). In general, El Nino years correspond to lower that average wet season floods (ie less extreme floods). La Nina years correspond to wetter than average wet season floods (ie more extreme floods; Delgado 2012).

Historic water infrastructure development

* Cochrane et al 2014 paper shows that hydrology of the system has changed in the period since 1991 as a result of water infrastructure in upper basin. The influence of water development on hydrology diminishes across gauge stations along a downstream gradient in the River, however effects are still seen at Prek Kdam including decreases in water rise and fall rates (23% and 11%, respectively) providing evidence for diminishing flood pulse in the Tonle Sap.

Global warming

* At the global scale strength (and variability) of El Nino cycles expected to increase with changing climate (Latif et al 2015). Extraordinary El Nino events like those in 1982/1983 and 1997/98 cause extreme weather around the world. Integrated climate modeling results demonstrates that El Nino events may be boosted by global warming. Modeling results shows stronger and more long lasting El Nino events.
* Interannual variability in flood levels have significantly increased during the 20th century (Delgado 2010, Rasanen et al 2013).

**Learning Exercise Instructions and Focal Questions**

Focal Questions:

* Are the hydrological results from the model consistent in direction, magnitude, and character with relevant research findings described above?
  + Examine MIMES outputs for the following lake pulse inputs
    - Pre- and post-1991 periods for water infrastructure results
    - 30-year historical time series
    - Climate change scenarios
  + Compare results to a repeated cycle (which observed year should be used or what parameters should be used to provide a modeled time series on water level?)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Metrics | Cochrane 2014 | Delgado 2012 | Rasanen and Kummu 2013 | Rasanen 2013 | Latif2015 |
| Rise rates | X |  |  |  |  |
| Fall rates | X |  |  |  |  |
| 30 day minimum | X |  |  |  |  |
| Dry season water levels | X |  |  |  |  |
| Wet season water levels |  |  | x |  |  |
| Wet season precip (esp June – Oct) |  | x | x |  |  |
| Wet season discharge (esp June – Oct) |  | x | x |  |  |
| Interannual variability in flood levels |  |  |  | x | x |
| Metric of “flood pulsiness” | suggested |  |  |  |  |
| Extent of observed dry and wet season |  |  |  |  | x |

**Follow-up questions**

* Consider the decision making contexts below, which baseline would be most appropriate to consider when running scenario analyses and why?
  + Decision making contexts
    - Basin-level zoning and landuse planning
    - Identification of no-fishing conservation zones
    - Consideration of mainstream dam development
    - Habitat protection around the lake floodzone

**Literature Cited**

Cochrane, T.A., M. E. Arias, and T. Piman. 2014. Historical impact of water infrastructure on water levels of the Mekong River and the Tonle Sap system. Hydrology and Earth Systems Science, 18: 4529–4541. doi:10.5194/hess-18-4529-2014

Delgado, J. M., Apel, H., and Merz, B. 2010. Flood trends and variability in the Mekong river, Hydrol. Earth Syst. Sci., 14, 407–418, doi:10.5194/hess-14-407-2010

Delgado, J. M., Merz, B., and Apel, H. 2012. A climate-flood link for the lower Mekong River, Hydrol. Earth Syst. Sci., 16, 1533–1541, doi:10.5194/hess-16-1533-2012

Latif M., V. A. Semenov, and W. Park. 2015. Super El Niños in response to global warming

in a climate model. Climatic Change, 132:489–500, doi: 10.1007/s10584-015-1439-6

Räsänen, T. A. and Kummu, M. 2013. Spatiotemporal influences of ENSO on precipitation and flood pulse in the Mekong River Basin, J. Hydrol., 476, 154–168, doi:10.1016/j.jhydrol.2012.10.028

Räsänen, T. A., Lehr, C., Mellin, I., Ward, P. J., and Kummu, M. 2013. Palaeoclimatological perspective on river basin hydrometeorology: case of the Mekong Basin, Hydrol. Earth Syst. Sci., 17, 2069–2081, doi:10.5194/hess-17-2069-2013